User's Manual for

GradeDec 2000

Version 1.0

Highway-Rail Grade-Crossing Investment Decision Support Tool

FEDERAL RAILROAD ADMINISTRATION

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Contents

Introduction

Introduction to GradeDec 2000

GradeDec 2000 is a decision support tool that assists federal, state and local authority decision makers in evaluating the benefits and costs of highway-rail grade crossing upgrades, separations, and closures. GradeDec 2000 employs benefit-cost methodologies that are used to evaluate highway-rail grade crossing investment alternatives at the corridor level. GradeDec 2000 utilizes modeling frameworks that were developed by the Volpe National Transportation Systems Center, the National Cooperative Highway Research Program and the Federal Railroad Administration. It enables the user to conduct sketch-planning level analyses that effectively support the planning and investment decision processes.

GradeDec 2000 forecasts the transportation and non-transportation effects of highway-rail grade crossing investments and estimates the economic value of these effects over the useful life of the project in dollar terms. The benefit-cost of an investment is calculated by comparing the time-stream of expected economic benefits with the time-stream of investment-related and other costs, after adjusting for the opportunity costs of capital. Known as "discounting", this adjustment enables decision makers to inspect future benefits and costs in terms of their *present-day* value. This is a standard way of giving due weight to nearer-term versus distant (thus less valued) outcomes.

GradeDec 2000's underlying methodology is consistent with the current benefit-cost methodologies employed by the United States Department of Transportation Agencies (Federal Railroad Administration, Federal Highway Administration, Federal Transit Administration, and the Federal Aviation Administration) and with Executive Order 12866 which governs the principles of federal infrastructure investment. The model is transparent in all of its assumptions and the model inputs are readily accessible to users who may want to adjust model inputs to reflect local circumstances.

GradeDec is designed to minimize the data needs and technical expertise required of the user while at the same time providing credible benefit-cost results. With information about a series of grade crossing improvements along a particular corridor, the range of anticipated accident reductions, train crossing delay improvements, and changes in travel demand generate preliminary benefit-cost results for a given confidence interval. Depending on the user's needs, requirements, and abilities, the user can select either an extensive default data base that will minimize input requirements, or the user can customize the results by inputting project specific localized data. In this way, GradeDec will function as both a high-level preliminary model and a micro-level localized model.

Why GradeDec 2000

Growing requirements for highway-rail grade crossing investments and dwindling fiscal resources point to the need for a new tool for investment analysis. GradeDec determines the effects rail corridor investments will have on safety and highway delay and queuing. Improvements will result in the following economic benefits:

- Improvement in safety and reduced accident costs;
- Reduced travel time costs;
- Improved air quality
- Improved system reliability measured as more predictable travel times;
- Reduced vehicle operating costs; and
- Network benefits.

GradeDec 2000 uses risk analysis to evaluate highway-rail grade crossing investments and the results of an analysis include probability distributions for all of the model outcomes. These outcomes are viewed with GradeDec 2000's user-friendly yet sophisticated displays of charts and statistics.

For a corridor-level analysis, GradeDec is able to evaluate up to 47 grade crossings simultaneously. The user can view model results in total by corridor or by individual grade crossings. For example, the user can view the safety benefits of each grade crossing improvement along the corridor and the probability range associated with those benefits. Likewise, the user can view the highway vehicle operating costs savings or environmental benefits for each grade crossing.

GradeDec conducts comprehensive statistical simulations in order to provide a probability range for the net present value associated with each rail corridor-level investment plan. This enables the user to assess the risk associated with each plan. Additionally, GradeDec conducts sensitivity analyses based upon the probability ranges and informs the user which factors will have the greatest impact on the outcomes. For each result the user can display a "tornado chart" that shows the ten most significant factors contributing to risk. This information is essential for planning contingencies and working to mitigate risks.

GradeDec thus provides important insight for planners and decision makers in prioritizing corridor investment plans. Two series of investments displaying an equal net present value may not offer equal promise if one exhibits a materially greater down-side risk of a low return.

In any "portfolio" there is a place for riskier investments; the important thing is to be aware of them and to chose them judiciously. GradeDec provides the management information needed to support decisions involving trade-offs between the expected return and the riskiness of investments.

New Features in GradeDec 2000

GradeDec 2000 includes a host of new features and these are listed here as interface and analytic improvements:

Interface Improvements

- The software is re-engineered entirely in Visual Basic 6.0 thus ensuring stability, Y2K compliance and compatibility with current and future versions of the Microsoft Windows™ operating system.
- The user interface is re-designed for ease of use and improved navigation and accessibility to data and assumptions.
- The user can custom tailor the data for each grade crossing and does not have to rely upon pre-defined grade crossing profiles.
- The risk analysis data input screen now provides a choice of probability distributions - skewed bell-shaped, or, uniform distribution.
- The new data input screen enables immediate visualization of the data.
- There is a seamless import/export interface with spreadsheet programs.

- The years dimension for data inputs adjusts dynamically to the user's definition - there is no scrolling through screens of placeholder inputs.
- The number of results variables adjusts dynamically to the number of grade crossings in an analysis. The software can accommodate up to 47 custom grade crossings in an analysis.
- There is a new chart format - the Tornado Chart - that displays the top ten input variables to which the risk of a result is most sensitive.
- The model reports all benefit results by benefits category for every grade crossing, and, for the corridor as a whole.

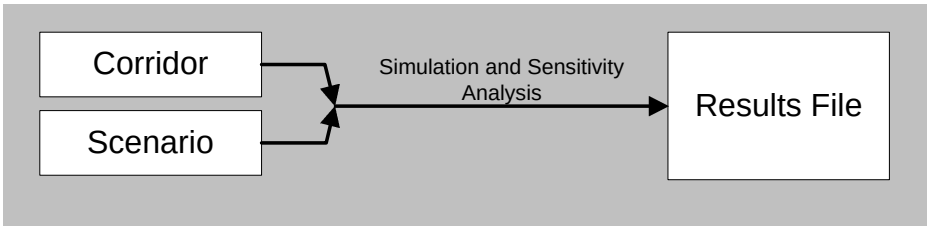
Analytic Improvements

- The GradeDec 2000 model includes DOT's Accident Prediction and Severity Formulas and these can be applied individually to each grade crossing so as to develop base year accident rates by type of accident.
- The model accounts for the correlation between the time-of-day distribution of traffic by rail and highway modes.
- The model re-assigns highway traffic when improvements involve closures and grade separations.
- The model calculates non-conventional, local benefits from grade crossing improvements.

GradeDec 2000 System Architecture

The diagram below presents an overview of the GradeDec 2000 system architecture. The system is designed for ease-of-use and conceptual clarity. The design enables novice and casual users to conduct meaningful analyses with relative ease while not requiring the user to wade through technically dense material. At the same time, expert users who want to take advantage of all of the system's features should find GradeDec 2000 useful for the comprehensive, sketch-planning analysis of corridor-wide grade-crossing improvements.

Main Process



File Structure

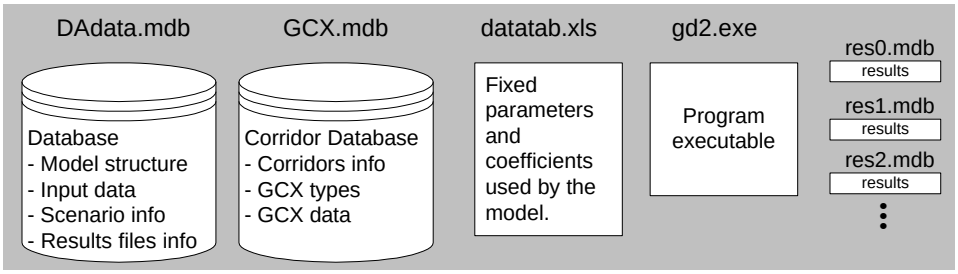


Figure 1 GradeDec 2000 System Architecture

GradeDec 2000 Objects

The functions of GradeDec 2000 center around several objects that are key components in every analysis. These objects are: the GradeDec 2000 model, corridors, scenarios and results files. When GradeDec 2000 is active, the system will always specify instances of these objects in its **Current Settings** (see below).

The following subsections describe the GradeDec 2000 objects.

The GradeDec 2000 Model

The GradeDec 2000 model is a defined set of input variables, result variables and the formulas and processes that generate the results. The model itself is deterministic, that is, for a fixed set of input values it generates a fixed set of results values. The GradeDec 2000 Reference Manual documents the GradeDec 2000 model.

The GradeDec 2000 program contains a simulation engine that samples from probability ranges on the input values and runs the model many times to generate many sets of results in a simulation, thus producing a probability distribution for each of the result variables. (The process of sampling from input variable distributions to evaluate the probability distributions of result variables is referred in this manual as "risk analysis", "simulation" and "Monte Carlo simulation").

When running a simulation, the GradeDec 2000 model is populated with data from two sources: the corridor and scenario specified in **Current Settings**. The model results are stored in the results file specified in **Current Settings**. Probability ranges can be assigned only to scenario data.

Corridors

A "corridor" refers to a collection of highway-rail grade crossings along a rail line that are the candidates for improvements or closure. In the GradeDec 2000 model and its documentation a grade crossing is often abbreviated as GCX.

A corridor definition includes an ID number assigned by the system, a corridor name, the length of the corridor in miles, the average number of trains per day and the number of switch trains, and a date/time number indicating the last modification of GCX data or corridor definition. A corridor contains at least one grade crossing and the model can accommodate up to a maximum of 47 grade crossings per corridor. Grade crossing data include the physical characteristics of the corridor, existing and proposed GCX types, GCX accident-related data and cost data.

The corridor definitions, GCX data and the GCX type definitions are stored in a database called GCX.mdb.

Scenarios

A scenario is a collection of data required for an analysis (i.e., every data element corresponds to a GradeDec 2000 model input variable). A scenario definition includes a system assigned ID, a name, a beginning year for an analysis, an end year for an analysis, and date/time specifying the last modification of scenario data.

The data belonging to a scenario have two distinguishing features:

- Scenario data are not specific to a particular GCX or corridor (one scenario can potentially serve in the analysis of more than one corridor), and,
- The data for a model input variable in a scenario can be one of the following: 1) a fixed value, 2) two values representing the minimum and maximum points of a uniform probability distribution, or, 3) three values that describe a bell-shaped probability distribution for the input variable.

All scenario data and definitions are stored in the DAdata.mdb database.

Results Files

The results of a risk analysis simulation and a sensitivity analysis are stored in a separate database file. The results file definition includes a system assigned ID and user-specified description. When a simulation is run, the results file definition is modified to include date/time of analysis, number of trials and random seed information.

Software Installation

Follow these instructions to install the software onto your system.

1. Insert CD ROM in the disk drive.
2. Click start, and select Run.
3. When the dialog box appears, type d:\gd2000\setup.exe and click **OK**.. (If your CD-ROM drive is different from d: then substitute the correct drive letter instead of d:).
4. Follow the installation instructions that appear on your screen.
5. If a message appears indicating that a file can not be copied because the destination file is in use, click on the **Ignore** button, your computer does not need this file. Installation will proceed normally after this. (The message indicating a destination file is in use and the need to click on **Ignore** may occur several times during installation).
6. Click **OK** when the installation is complete. You are now ready to begin using the software.

System Requirements

The hardware and software requirements to run the software are given below.

- Intel Pentium family computer running the Windows 95/98, or, Windows 2000 operating systems.
- A minimum of 16 MBytes total memory.
- Hard disk space required for installation is 15 MBytes.

Software Performance and System Hardware

Systems meeting the minimum specifications should perform most functions with near-instantaneous speed. However, the speed of a simulation on minimally configured systems may be slow.

In general, systems with more memory and faster CPUs will run simulations faster. The time to complete a simulation will depend upon a) the number of grade crossings in a corridor, and, b) the number of trials in a simulation.

As a benchmark, a computer with a 350 Mhertz processor and 64 Mbyte RAM will run 500 simulations with 10 grade-crossings, including sensitivity analysis, in under 25 seconds.

Manual Overview

The remainder of this document describes each of the main screens that are encountered during a grade-crossing investment analysis. These screens appear in the following order: the **Settings** screen, **Corridors** screen, **Scenarios** screen; **Simulation** screen, and the **Results** screen.

The Settings Screen

Settings Screen Overview

The **Settings** screen, pictured below, is the first screen that appears when the program is invoked by double clicking on the *GradeDec 2000* icon from the Windows Start menu. From the **Settings** screen you can: 1) navigate among the corridors, scenarios and results files; 2) modify corridor, scenario and results files definitions; 3) launch other screens and functions.

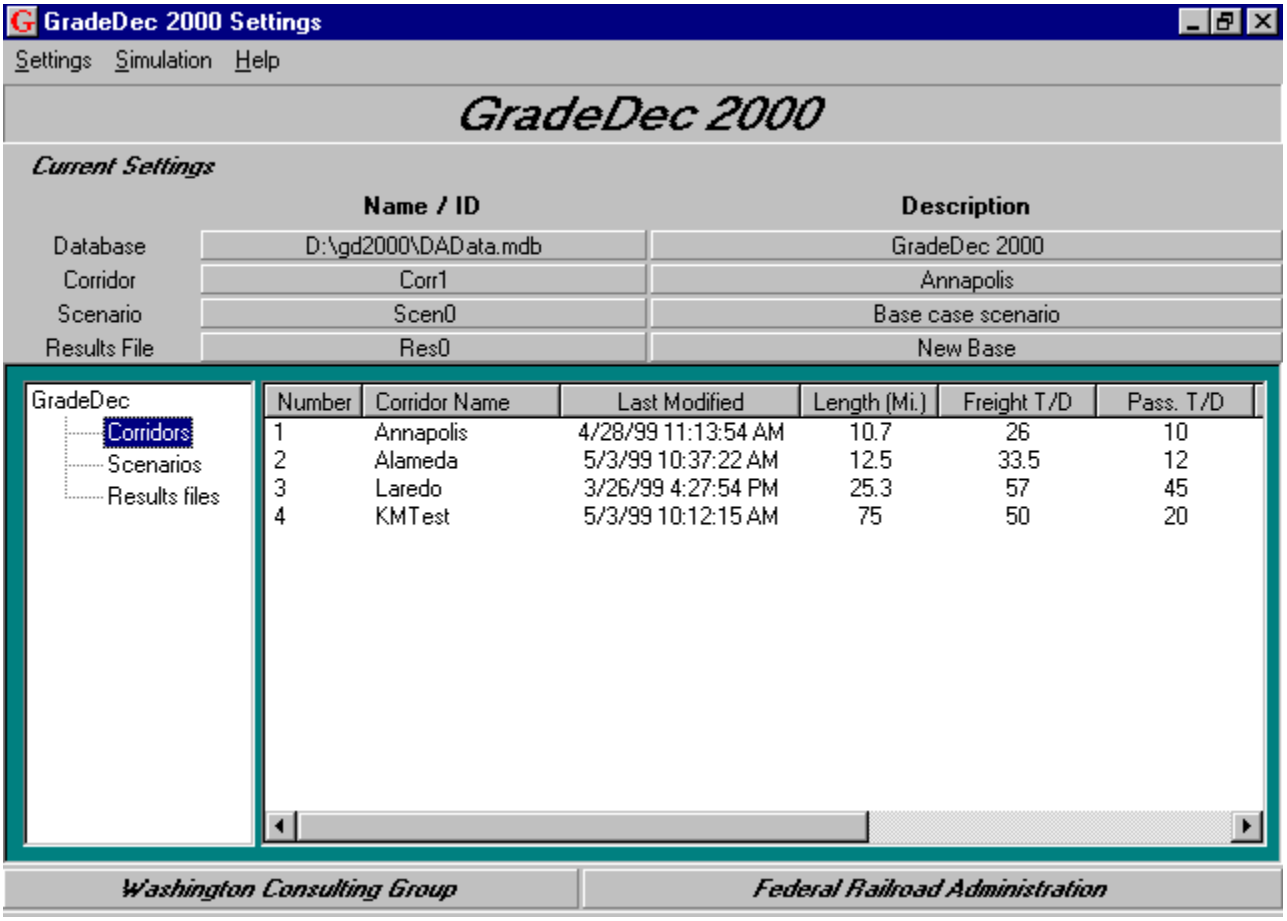


Figure 2 Settings Screen

The **Settings** screen is divided into three main sections: 1) **Current Settings** (top of screen), 2) the **Object Tree** (lower left)**,** and, 3) the **Item List** (lower right). In addition, at the top of the screen is a menu that provides access to the "Settings" submenu, "Simulation" and on-screen "Help" options.

Current Settings

The **Current Settings** are the settings that will be used, if left unchanged, in the next simulation. Four components make up the **Current Settings.** These are: database, corridor, scenario and results file. The **Current Settings** show a "Name/ID" and description for each setting. The database name should always show a file name "DAdata.mdb" along with the path (which is the default path) where all the files required for an analysis are stored.

When GradeDec 2000 opens it shows the defaults as the **Current Settings** (the defaults are discussed below). The **Object Tree** shows "Corridors" as the selected node and the **Item List** lists the corridors from the corridor database in the default path folder.

Changing settings

There are two steps to changing settings:

- Select a node of the **Object Tree** (either "Corridors", "Scenarios" or "Results files"). Selecting the node shows a listing of the selected object in the **Item List.**
- Select an item in the **Item List.** The selected item will appear in the **Current Settings**.

The user "selects" a node of the **Object Tree** or an item in the **Item List** by moving the mouse pointer to the node or item and clicking.

Settings Menu

Select the database

With the "Select the database" option from the Settings Menu, you can change the database and folder from which GradeDec 2000 accesses data and writes to files. Choose the "Select the database" option and use the dialogue box to specify the new folder and database, then click "Ok".

Recommended Practice: If you want to preserve an analysis, create a new folder and copy all of the files from your working folder (except the gd2.exe program executable) to the new folder. Then choose the "Select the database" menu option and select the DAdata.mdb database in the new folder. All subsequent work will be recorded in the new folder (until you exit and re-enter the program, or, restore the defaults). Save the new settings as defaults if you want to continue working in the new folder.

View or edit data tables

Choosing this option displays data tables that contain parameters and coefficients used by the GradeDec 2000 model. These parameters and coefficients are described in the GradeDec 2000 Reference Manual. In general, the non-expert user should not

change these values. These values can be changed and then saved using the "File save" option in the Data Tables form menu.

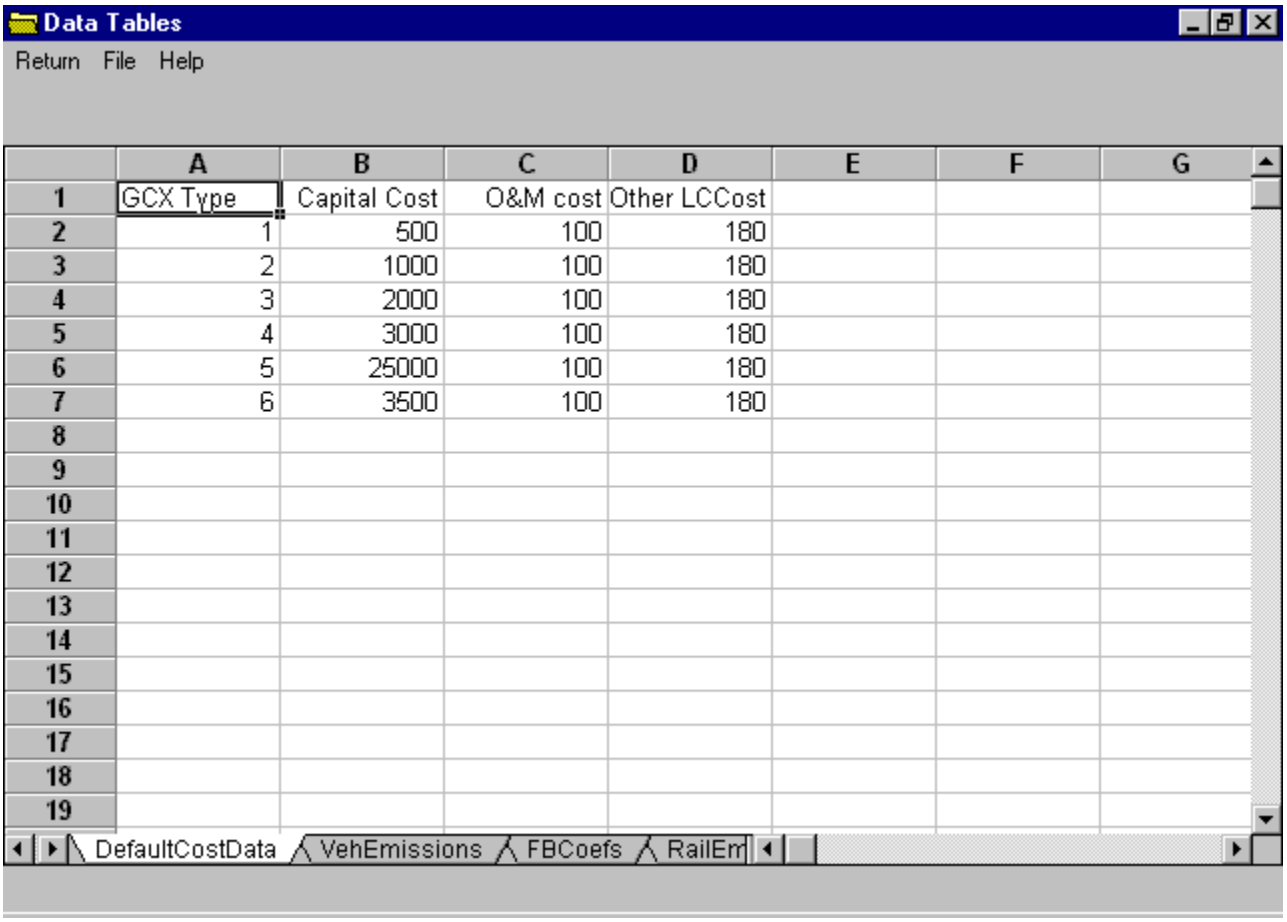


Figure 3 Data Table Screen

Recommended Practice: If you want to change values in the data tables, use the "Save as" option to save the data tables under a new name. Make your changes and then save the data tables with the "Save" option. The "Save" option saves the data with the name "datatab.xls" and the file with this name is always used by the program. The file you saved under the new name is preserved as a backup.

Note: Take care not to add rows or columns to the spreadsheets in the table. If you modify "datatab.xls" using Microsoft Excel you must save the spreadsheet in Excel 5.0 format.

Defaults - saving and restoring

The default settings are those that appear when GradeDec 2000 is opened. The settings include: database, corridor, scenario and results file. You can restore the default settings by choosing "Defaults-Restore" from the "Settings" menu. You can also make your current settings the default settings by choosing the "Defaults-Save" option from the "Settings" menu.

Compact database

The “Compact Database” option in the “Settings” menu will remove empty space from your database file. If you conduct many analyses with numerous scenarios you may improve the speed of some of GradeDec 2000’s functions by occasionally running this option.

Deleting - corridor, scenario, results file

The “Delete” options in the “Settings” menu will delete the corridor, scenario or results file that is specified in the **Current Settings**. Select the corridor, scenario or results file you wish to delete before choosing the “Delete” option.

“Delete Corridor” will delete the corridor definition and all associated GCX data will be deleted from the GCX.mdb database. “Delete Scenario” will delete the scenario definition and all data associated with the scenario in the Dadata.mdb database. “Delete Results File” will delete the selected results file and its definition in the DAdata.mdb database.

Note: You cannot delete a corridor, scenario or results file if it is designated as the default. In order to delete a default setting, first make it non-default by saving new settings as defaults.

Simulation and Help

The “Simulation” option in the Settings Screen Menu launches the **Simulation Screen**. The “Help” option provides access to the GradeDec 2000 help file system.

Object Tree

When the **Settings Screen** is shown , the selected node on the **Object Tree** specifies the content of the display on the **Item List.** For instance, when the “Corridors” node on the **Object Tree** is selected the **Item List** displays a list of the defined corridors.

Selecting an object

Clicking on a node of the **Object Tree** will select one of the three GradeDec objects: Corridors, Scenarios, or Results Files. After selecting an object, the **Item List** will contain all of the items associated with the selected object that are contained in the database appearing in **Current Settings.**

Modifying definitions - corridors, scenarios, results files

By double-clicking or pressing “Enter” on an **Object Tree** node you invoke a form which enables you to modify descriptions and other designated attributes of an object’s items. Specifically, for each object, double-clicking will allow modification of the following:

- **Corridors** - Modifiable information includes corridor name, length in miles, average number of trains per day, number of switch trains.

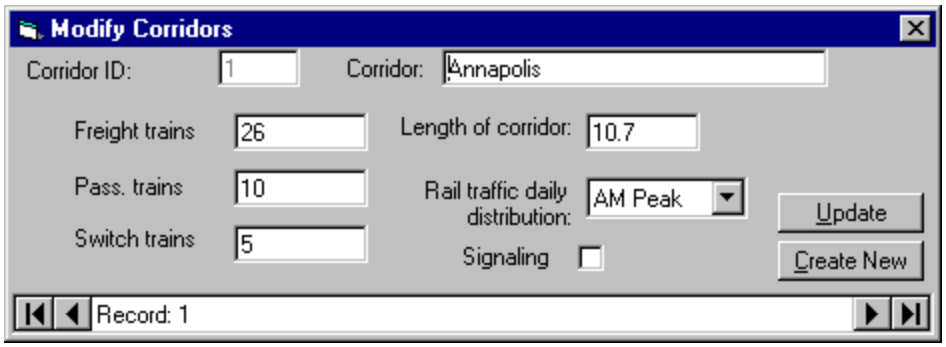


Figure 4 Modify Corridors Definition Form

- **Scenarios** - Modifiable information includes scenario description, first year of analysis and last year of analysis (the earliest "first year" is 1998 and the latest "last year" is 2050).

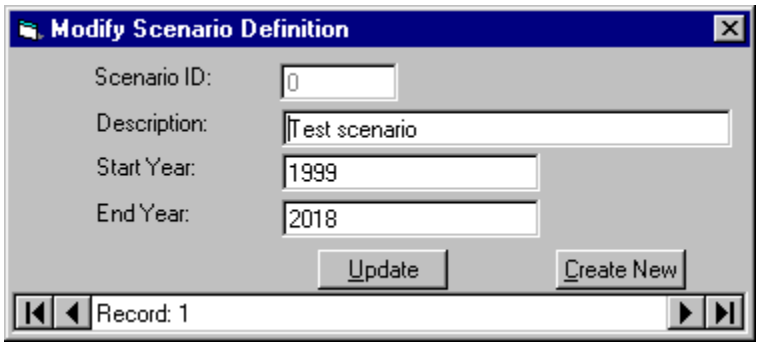


Figure 5 Modify Scenarios Definition Form

- **Results Files** - Modifiable information includes the description of the results file.

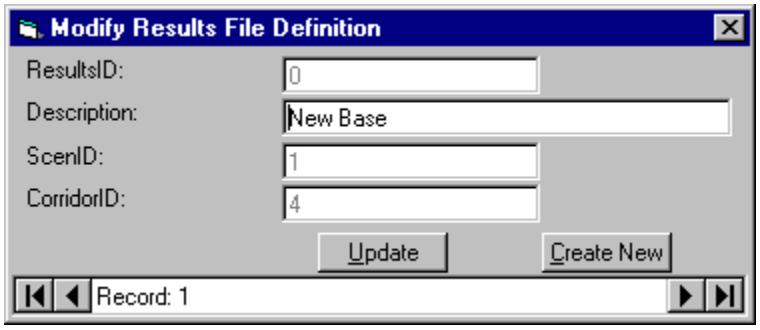


Figure 6 Modify Results File Definition Form

After changing information in the appropriate text box in the form, you must press the "Update" button on the form. Exit the forms by clicking on the "X" in the upper right hand corner.

Creating new corridors, scenarios, results files

You create new corridors, scenarios and results files through the **Object Tree.** First, invoke the "Modify" form by double-clicking on an **Object Tree** node. Then choose

the button labeled “Create New”. This will invoke a “Create New” form and you complete the forms as follows:

- **Corridors** - In the “Create New Corridor” form you enter the description of the corridor, the number of trains per day, the number of switch trains and the length of the corridor in miles. Numeric values can be non-integer (i.e., 10.7). Press “Create” after filling in the fields on the form.

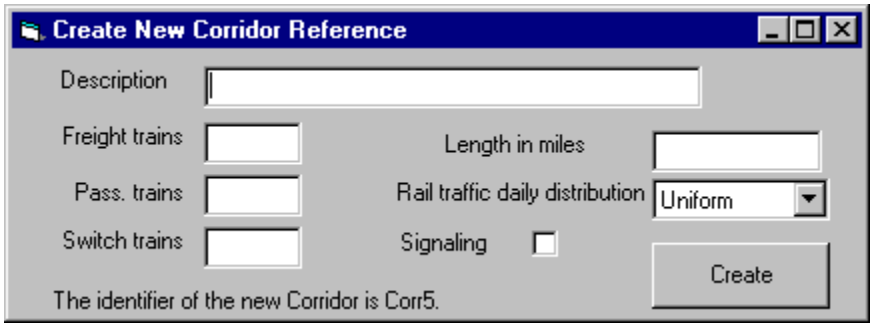


Figure 7 Create New Corridor Form

- **Scenarios** - In the “Create New Scenario” form you need to specify the description, the start year of the scenario and its end year. You must also specify whether to set all data values to zero, or, copy data values from an existing scenario. If you choose the “Copy Data” option, then you must specify an existing scenario using the pull-down menu in the form. Press “Create” after completing the form.

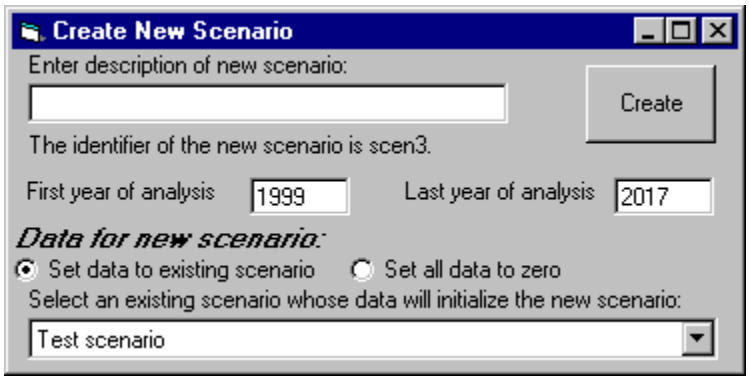


Figure 8 Create New Scenario Form

- **Results Files** - In the “Create New Results File” you need to specify the file description and press the “Create” button.

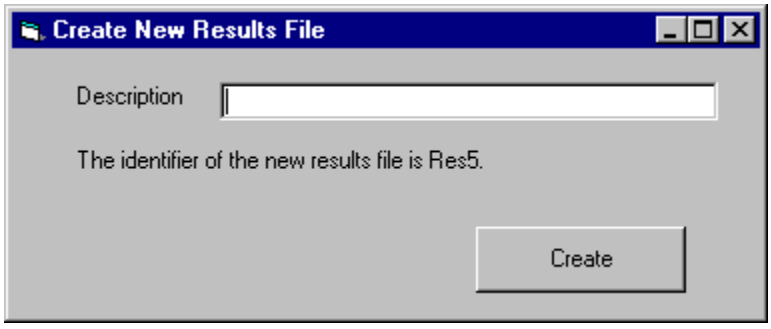


Figure 9 Create New Results File Form

Item List

The **Item List** displays a list of the items that are associated with the object that is selected in the **Object Tree**. Along with each item, the **Item List** shows all of the definitional information associated with the item. Using the **Item List** you can change the settings for the corridor, scenario and results file

Selecting - corridor, scenario, results file

Clicking on the item number selects that item and makes it the current setting. For instance, if the list displays "Scenarios" and you click on number 2 then that scenario becomes the current scenario.

After selecting an item, you can move up and down the list using the arrow keys. Moving with the arrow keys also changes the selected item.

Viewing/Editing - corridor, scenario, results File

Double-clicking on an item in the list will launch the screen that enables viewing or editing that item. Specifically:

- Double-clicking on a corridor in the **Item List** will launch the **Corridor/GCX Screen** for viewing and editing GCX data within the corridor.
- Double-clicking on a scenario in the **Item List** will launch the **Scenario Data Input Screen** for viewing and editing scenario data.
- Double-clicking on a results file in the **Item List** will launch the **Result Screen** for viewing results tables and charts.

The Corridor/GCX Screen

Corridor/GCX Screen Overview

The Corridor/GCX Screen, pictured below, is invoked by double clicking on a corridor in the **Item List** from the **Settings Screen**. In the **Corridor/GCX Screen** you can:

- View GCX data for the selected corridor
- Add, modify and delete GCX data.

The **Corridor/GCX Screen** is divided into two main sections: 1) the **Corridor/GCX Data Form** (top of the screen), and, 2) the **Item List** (bottom of the screen). You use the **Item List** to select a GCX to view or edit. Data entry and modification to GCX data are entered on the data form. The buttons on the form facilitate data entry for accident data and cost data. After modifying data use the "Update" button to save your changes. Other features can be accessed with the **GCX/Corridor Menu** at the top of the screen.

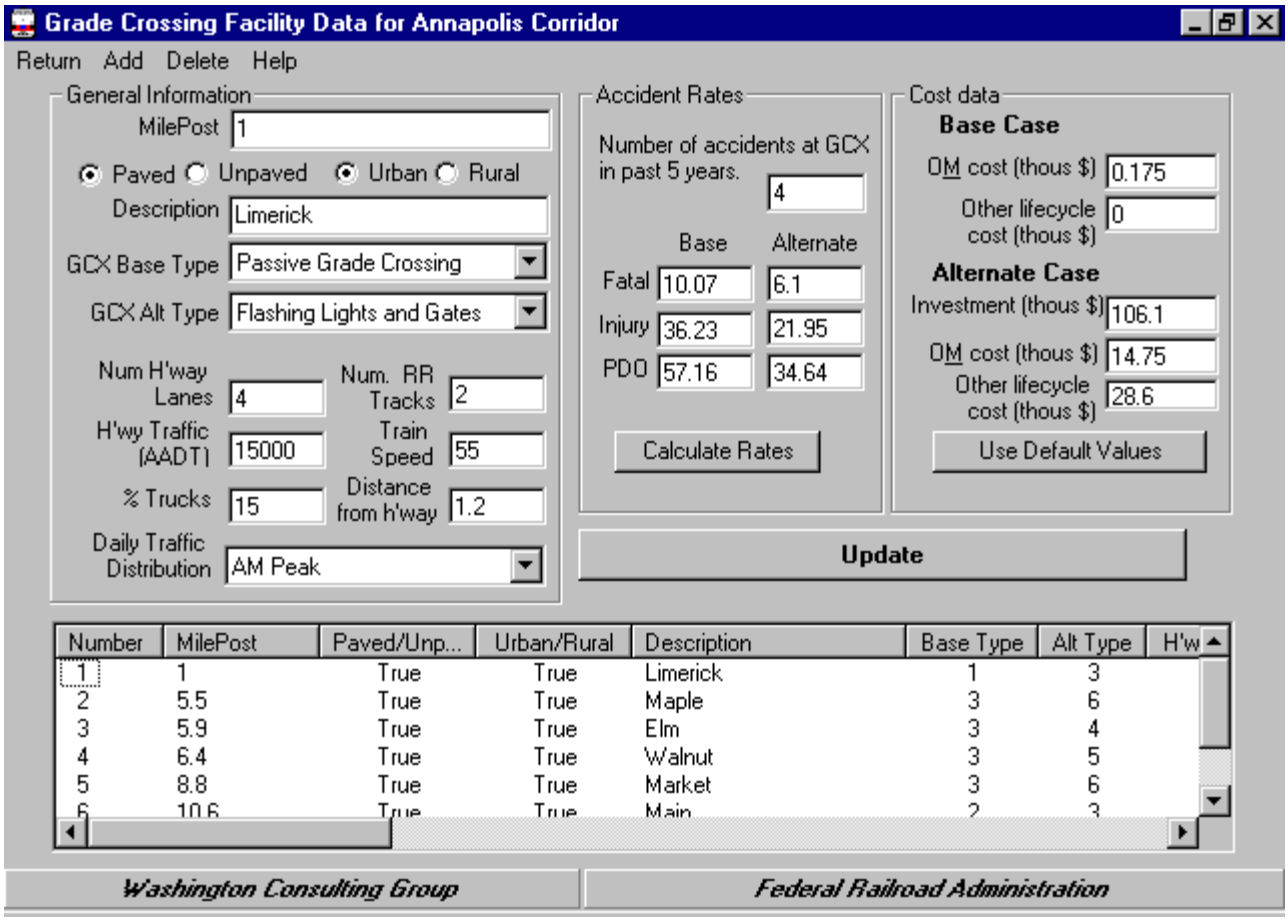


Figure 10 The Corridor/GCX Screen

Corridor/GCX Data Form

GCX data entry

Using the mouse click on the field where you wish to enter data. For "GCX Type", use the pull-down menus. After completing the general information and entering the number of accidents at the GCX, press "Calculate Rates" to compute the predicted rate of accidents at the GCX. Specify cost data using the "Use Default Values" button, or, enter data manually if there is better information for the grade-crossing.

"Calculate Rates" button

The "Calculate Rates" button uses the Department of Transportation Accident Prediction and Accident Severity formulas to calculate the accident rates. The corridor information, the general information for the GCX and the GCX accident history are all used to calculate the predicted number of accidents by severity. The predicted number of accidents by severity are then divided by the "exposure", that is, the number of trains per day times the average annual daily traffic on the highway (AADT). The result of this calculation is then multiplied by 100 million to yield the "number of fatal/injury/other accidents per 100 million daily exposures".

For more details, see the GradeDec 2000 Reference Manual.

“Use Default Values” button

The “Use Default Values” button sets the cost data on the form based upon the choice of GCX type and the default cost values that are included in the data tables (see Data Tables under **Settings Menu**).

“Update” button

After entering or modifying the data for a grade-crossing, pressing the “Update” button saves the new data in the corridor data base. If you move to another GCX in the item list or exit the screen without pressing the “Update” button, you will lose any information that you entered since you last pressed “Update”.

Note: Pressing the "Update" button *does not* recalculate the accident rates based upon new or changed GCX or corridor data. In order to recalculate the rates and save them in the GCX database you must: 1) Press the "Calculate Rates" button and then 2) Press the "Update" button.

GCX Item List

Select GCX

Click on the number column to select an item on the GCX Item List. This will display the GCX information on the Corridor/GCX Data Form.

Corridor/GCX Menu

Return

Choosing the “Return” option will send you back to the **Settings Screen.**

Add

Choosing the “Add” option in the menu will give a blank form for entering data for a new GCX. If you enter a milepost that already exists, the new data that you enter will overwrite the existing data for the GCX when you press “Update”. Otherwise, pressing “Update” will record the new GCX in the corridor database.

Delete

Choosing the “Delete” option will delete the data for the GCX.

Scenario Input Screen

Scenario Input Screen Overview

The **Scenario Input Screen** is where you view and edit scenario data for the analysis. Scenario data for the model input variables can be either fixed values, or, two or three values that describe a probability distribution.

This screen of GradeDec 2000 possesses a number of features that lets you easily visualize the data and lets you quickly arrive at probability distributions that best reflect your information and beliefs regarding future developments. These features include:

- Ease of navigation among variables;
- Instant viewing of statistics and charts
- Instant validation and saving of ranges
- Seamless connectivity with spreadsheet software.

The **Scenario Input Screen** is shown below. The variables in GradeDec are organized into data sets with variables in each data set sharing some common attribute. When you invoke the **Scenario Input Screen** the first data set is loaded and the first variable in that data set is selected and shown in the chart and tables.

The remainder of this section describes each component of the **Scenario Input Screen** and their functions.

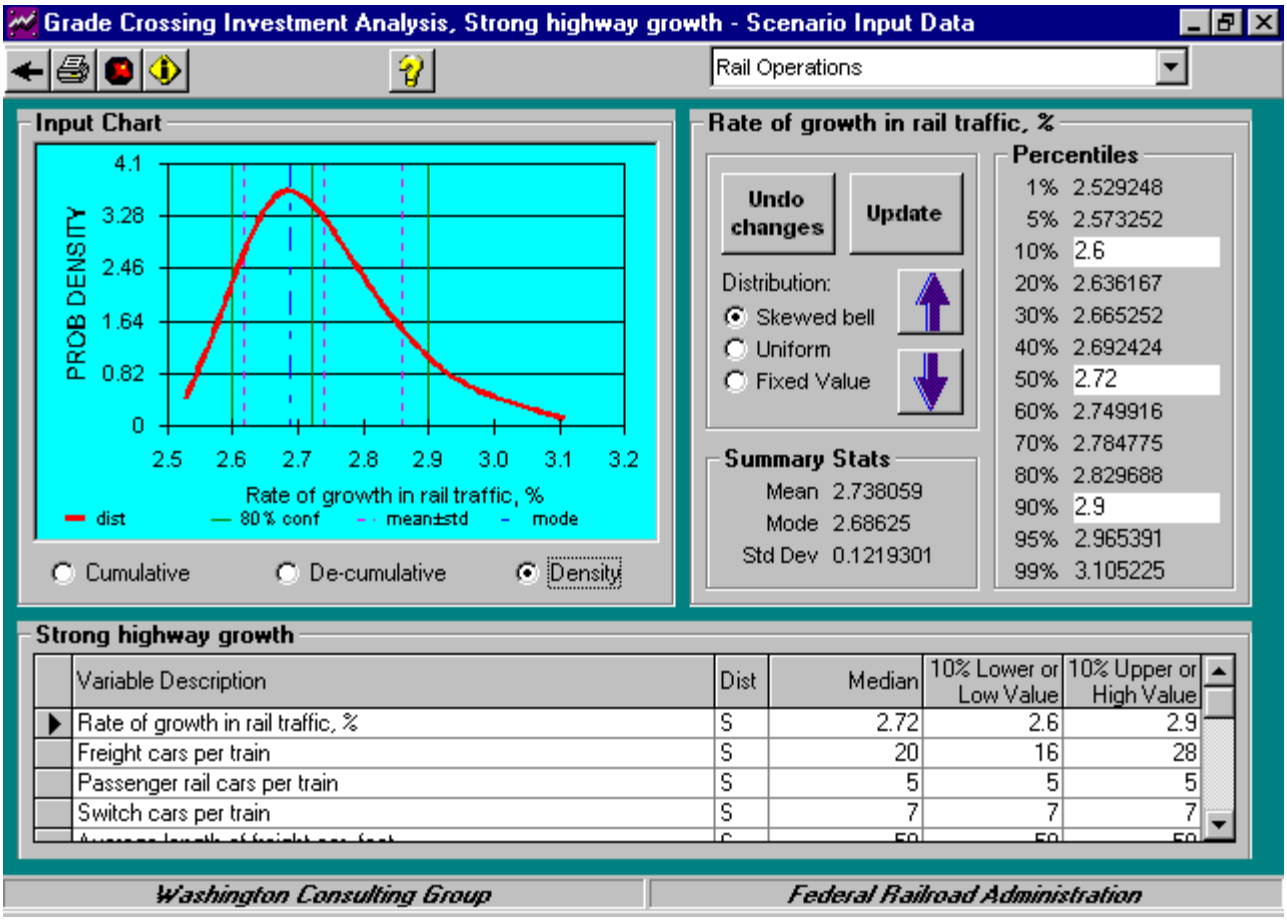


Figure 11 The Scenario Data Input Screen

Toolbar

The toolbar at the top of the screen contains several icon buttons that perform the following functions.

Return to Settings

The left arrow button will exit this screen and return you to the **Settings Screen"**

Print

The print button prints a snapshot of the screen. It invokes your system's printer dialogue box from which you can set your printer settings.

Export

The export button sends all of the scenario data to a Microsoft Excel 5.0 spreadsheet. The scenario data will include one row for each variable and the following columns: a) variable name, b) the 50% value, c) the 10% value, d) the 90% value and e) the distribution type.

Import

In order to import data you must open an exported scenario file in a spreadsheet program, make your changes to the data, select the range of data to import and copy it to the clipboard (Ctrl+C or "Edit-Copy" in most programs).

The range you select must include the columns noted in the "Export" section above. You should not include the column header. For instance a2..e6 is a valid range to select. a1.. e6 is not because it includes the row with the column header.

When you press import, a message box will appear asking whether you have copied the data to import to the clipboard. Assuming you have, press "Ok". A GradeDec 2000 spreadsheet will appear and you have another opportunity to modify the data to import. When you are ready, click the "Import" button to import the data.

Data set pull-down menu

Using this pull-down menu in the upper-right-hand corner of the screen, you select the data set to view and edit.

Input chart area

The chart area contains the chart that corresponds to the data for the selected variable. The chart will update automatically when the data is changed or a new variable is selected. For a fixed value, the chart will display the message "No Chart for Fixed Value". The three chart types are described here. Each of the three chart shows vertical lines that represent: the mean value, the mean value plus and minus the standard deviation, the mode of the distribution and the values for the 10, 50 and 90 percentiles. The x-axis on all the charts range between the 0.5 percentile and the 99.5 percentile. The different chart types are selected using the option buttons located beneath the charts.

Cumulative

Chart of the cumulative probability distribution -- see glossary for definition.

De-cumulative

Chart of the de-cumulative probability distribution -- see glossary for definition.

Density

Chart of the probability density function -- see glossary for definition.

Container frame

The upper-right of the **Scenario Input Screen** shows the control panel, the summary statistics and the percentiles. The three items are contained within a frame whose caption will always display the description of the selected variable.

Summary statistics

The summary statistics frame displays the mean, mode and standard deviation of the distribution. See the glossary for the definitions.

Percentiles and data input boxes

The percentiles frame displays the percentiles of the distribution. When the option button in the control panel is set to "Distribution", a bell-shaped distribution is shown that passes through the 10-50-90 values that the variable data specify. When the option is set to uniform, the percentile table changes to show that the upper and lower values are the 0 and 100 percent values, respectively, and the median value is the average of the upper and lower values.

For the data input boxes, the following apply when the appropriate option button is selected:

- **Distribution** - All three values must be set and these are 10-50-90 percentile values, respectively.
- **Fixed Value -** Only the middle data box can be modified. The other two will show "n/a". When saved, the 10-50-90 values will all be identical.
- **Uniform** - Only the upper and lower values can be modified. The middle data box is disabled and its value is automatically set as the average of the upper and lower values.

Control panel

The Control Panel contains the "Accept" and "Restore Previous" buttons and the "Distribution-Uniform-Fixed Value" option buttons.

"Distribution-Uniform-Fixed Value " option buttons

These option buttons determine whether the data for the variable will describe a fixed value, a uniform distribution or a bell-shaped distribution.

"Update" and "Undo Changes" buttons

After you set the distribution type and enter the data, you save the data for the variable you are viewing by pressing "Update". "Update" tests that the data is valid (i.e., 10-50-90 values are increasing) and then saves the data for the variable in the database. Use the "Undo Changes" button to restore the data from the last update.

"Next variable" button

Pressing the button with the down arrow icon selects the next variable in the data set.

Previous variable

Pressing the button with the up arrow icon selects the previous variable in the data set.

Variable data grid

The variable data grid is displayed at the bottom of the screen. It displays a list of the variables in the data set, the distribution type of the data (S for the standard bell-shaped distribution and U for the uniform distribution), and the three values: Median, 10% lower (or low value for uniform distribution) and 10% upper (or high value for uniform distribution). You can scroll, point and click at a variable in the variable

data grid to select it (as an alternative to moving with the arrow buttons in the toolbar).

The pointer at the left side of the variable data grid always points to the currently selected variable. The frame containing the variable data grid will always show the name of the scenario you are viewing.

Navigating the Scenario Data

You navigate among the scenario data with the use of the controls that were described above:

- The data set pull-down menu lets you select the subset of data from within the scenario where you want to focus your attention.
- You can use the up and down arrow buttons in the tool bar to move to any variable within the data set. Note that when you select a variable its data values appear in the data boxes in "Percentiles", its description will show in the caption of the upper right container frame and, the data variable grid pointer will always point to the selected variable.
- You can scroll to the variable you want to view with the variable data grid and point and click on the variable to select it.

Entering Scenario Data

The section describes entering data one variable at a time directly on the **Scenario Input Screen.** Alternately, you can enter data from a spreadsheet and import it. (see the following section).

After selecting a variable, its values will show in the data boxes in the upper right hand of the screen. The chart, statistics and status of the control panel option buttons will reflect the data currently associated with the variable.

First, decide whether you wish to change the option button (change the distribution type or make the input a fixed value). If you change from a fixed value to uniform or distribution, the appropriate boxes for data entry will be enabled for data entry. If you change from "Distribution" to "Uniform", the 10 and 90 values become the low and high values of the uniform distribution and the median is overwritten with the mid-point between the high and low values. Likewise, if you change from "Uniform" to "Distribution", the 0-50-100 points of the uniform distribution become the 10-50-90 points of the bell-shaped distribution.

After you have chosen the distribution type modify the input data in the data boxes. If you wish to restore the previous values, press "Restore Previous". After you are satisfied with the new data values press "Accept". When you press "Accept" the new values have been saved. If you don't press "Accept" and move to a new variable, or, leave the screen you will lose any changes you have made to the variable data.

Exporting to and Importing from a Spreadsheet

Exporting and importing data via a spreadsheet is useful when you are initializing a scenario and wish to modify much of a scenario's data. After importing data you can then review the data one variable at time as a check.

To export data just press the "Export" button in the tool bar at the top of the screen.. A dialogue box will appear that will enable you to specify a file name and path. The file will be saved in Microsoft Excel 5.0 format. After exporting the scenario data, you can go to your spreadsheet program and open the file you saved.

After you have changed the data in the spreadsheet, select the data you wish to import and copy it (Ctrl+C or "Edit-copy" in most spreadsheet programs). Return to the GradeDec 2000 program, return to the **Scenario Input Screen** and press "Import" from the tool bar. See the Import and Export descriptions in the tool bar section above.

Printing the Scenario Inputs Screen

Press the "Print" icon on the toolbar to print the screen. This will invoke your printer's print dialogue box and you can change your print settings and then click on "Ok" to print.

Simulation Screen

Simulation Screen Overview

You use the **Simulation Screen** to set simulation parameters and begin a simulation. The **Simulation Screen** is invoked from the **Settings Screen** menu. The screen appears overlaid on the **Settings Screen** thus allowing you to view the **Current Settings** when setting the simulation parameters.

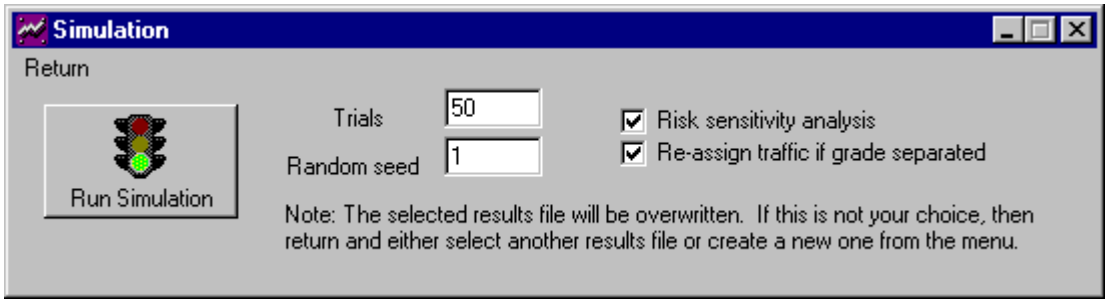


Figure 12 Simulation Screen

The sections below describe the components of the **Simulation Screen** and the steps involved in running a simulation.

Trials Box

Enter the number of trials for the simulation. The number of trials is the number of times that the program will sample from the input distributions, solve the model and generate results. Generally speaking, more trials will yield more stable results and will take more time to run. 500 trials in most cases is adequate. There is no practical limit to the number of simulations you can run. GradeDec 2000 has been tested with up to 20,000 trials for 10 grade-crossings.

Random Seed Box

The random seed determines the sequence of pseudo-random numbers that are generated by the simulation engine. Any integer value will generate a unique sequence of pseudo-random numbers for the simulation.

Changing the random seed is an expert option. You may want to change the random seed to test the effects of the randomness of the Monte Carlo sampling on the outcome distributions.

Risk Sensitivity Analysis Check Box

The risk sensitivity analysis runs the GradeDec 2000 model with all the input variables except one set to their mean values. The exception input variable is set to its 10 percent lower value and the model is solved. The input variable is then set to its 10 percent upper value and the model is solved again. This process is repeated for all input variables. The results of the sensitivity analysis are displayed in the tornado charts which is invoked from the **Results Screen**.

"Re-Assign Traffic, If Grade Separated" Check Box

In GradeDec 2000, there is an algorithm that re-assigns traffic from the adjacent grade crossings to an improved crossing with grade separation. This box is checked by default and you can choose to run your simulation without the re-assignment of traffic.

"End of Simulation" Screen

The **End of Simulation Screen** is shown below. From this screen you can either return to the **Settings Screen** or go directly to the **Results Screen.**

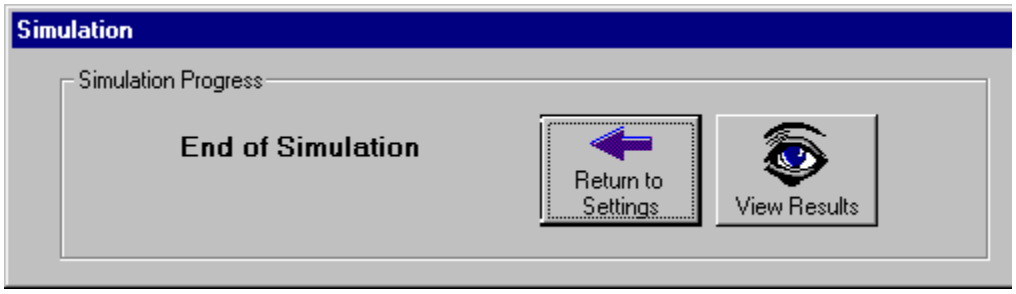


Figure 13 Simulation Completed Screen

Results Screen

Results Overview

The results of a simulation are viewed in the **Results Screen**. The screen is shown below. When the screen opens it shows the first results data set and the first variable in that set.

The following sections describe the components and functions of the **Results Screen.**

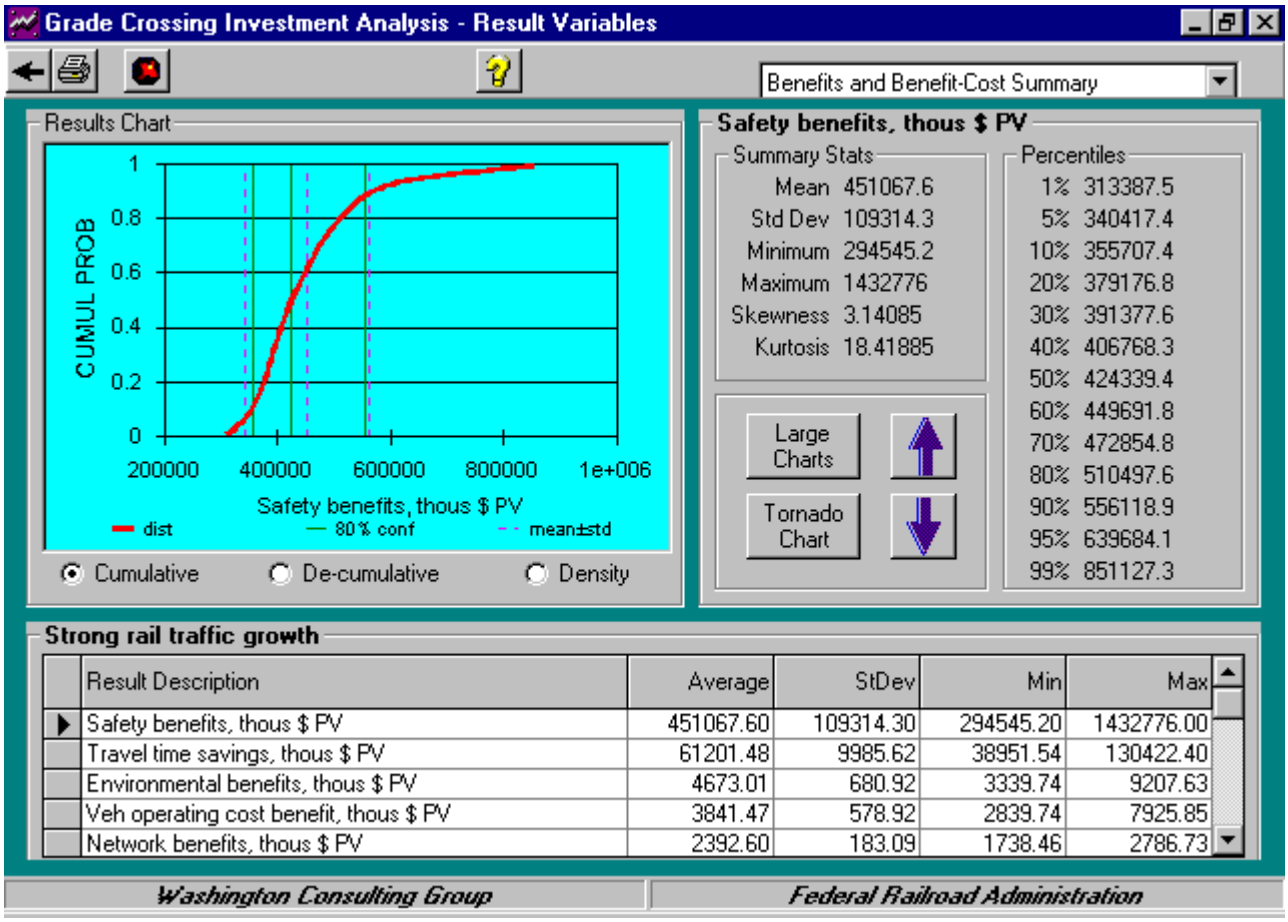


Figure 14 Results Screen

Navigating the Results

You can navigate among the results by selecting the results data set with the pull-down menu in the upper right-hand corner of the screen. Use the up and down arrows to find the variable of interest. Alternately, you can scroll, point and click to the results variable of interest in the results data grid at the bottom of the screen.

When a result is selected its statistics are shown in the tables on the screen as well as its summary chart. Using the option buttons you can choose to display either the cumulative, de-cumulative or density charts. The summary charts do not use all of the simulation data, rather, only the summary statistics in the tables are plotted in the charts. The large charts plot all of the simulation result data from all trials of the simulation. To view these, press the “Large Charts” button after selecting the result variable of interest.

Large Charts

The large charts display all of the result values from each trial of the simulation. When you press the "Large Charts" button, the histogram chart is displayed. This chart has its number of bins set to 30. You can modify the granularity of the histogram by changing the number of bins using the "Bins" option in the menu that appears on the "Large Charts" screen. By pointing and clicking on a particular bin you can view the probability of the result falling within the bin's range

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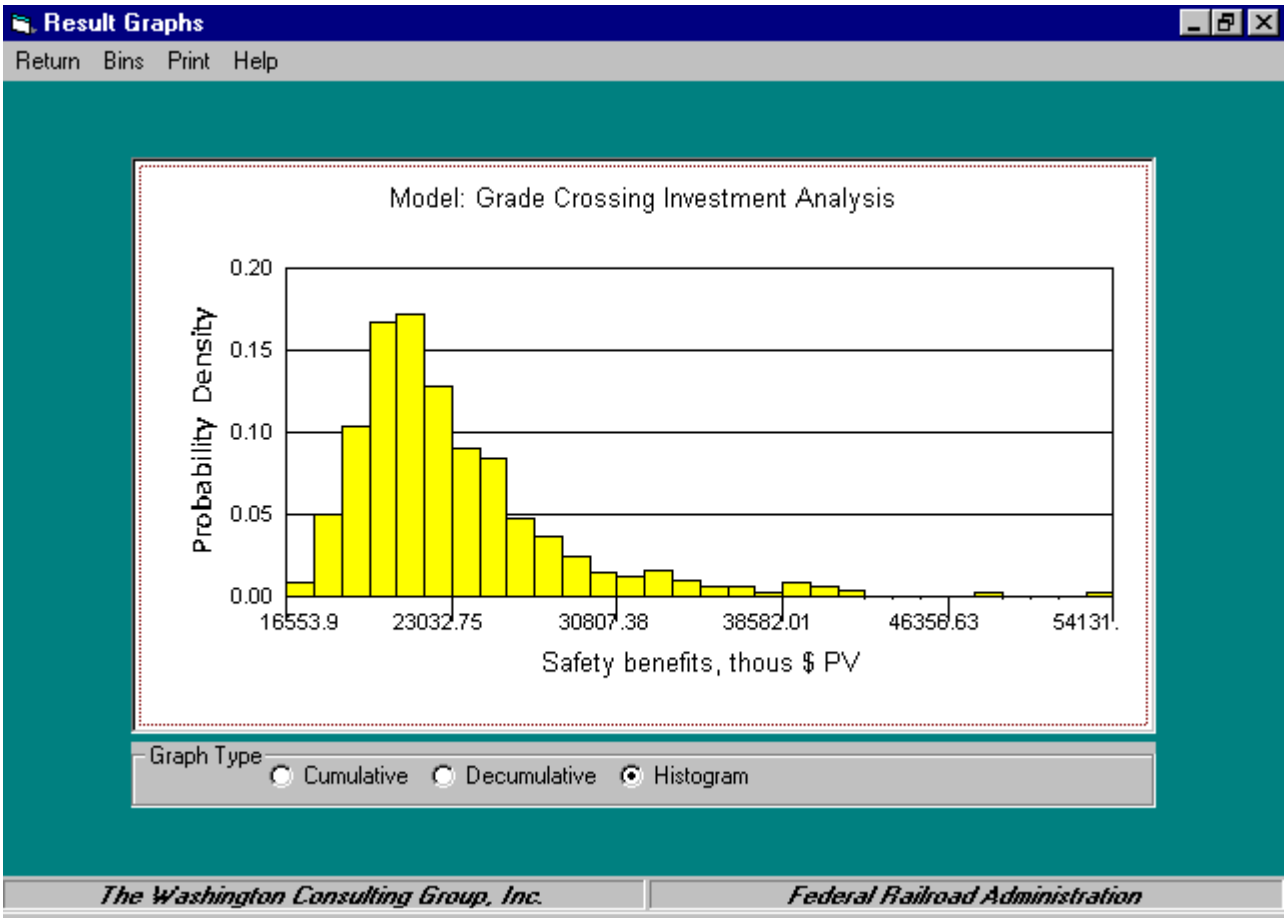

Figure 15 Histogram Chart

Choose the “De-cumulative” option button to view the de-cumulative chart. This chart shows the full range of values for the selected result and the probability of exceeding each value in its range. Pointing and clicking on a point of the curve will display the coordinates of that point. You can move to adjacent points after displaying a point by pressing the “n” key (for next) or “p” key (for previous).

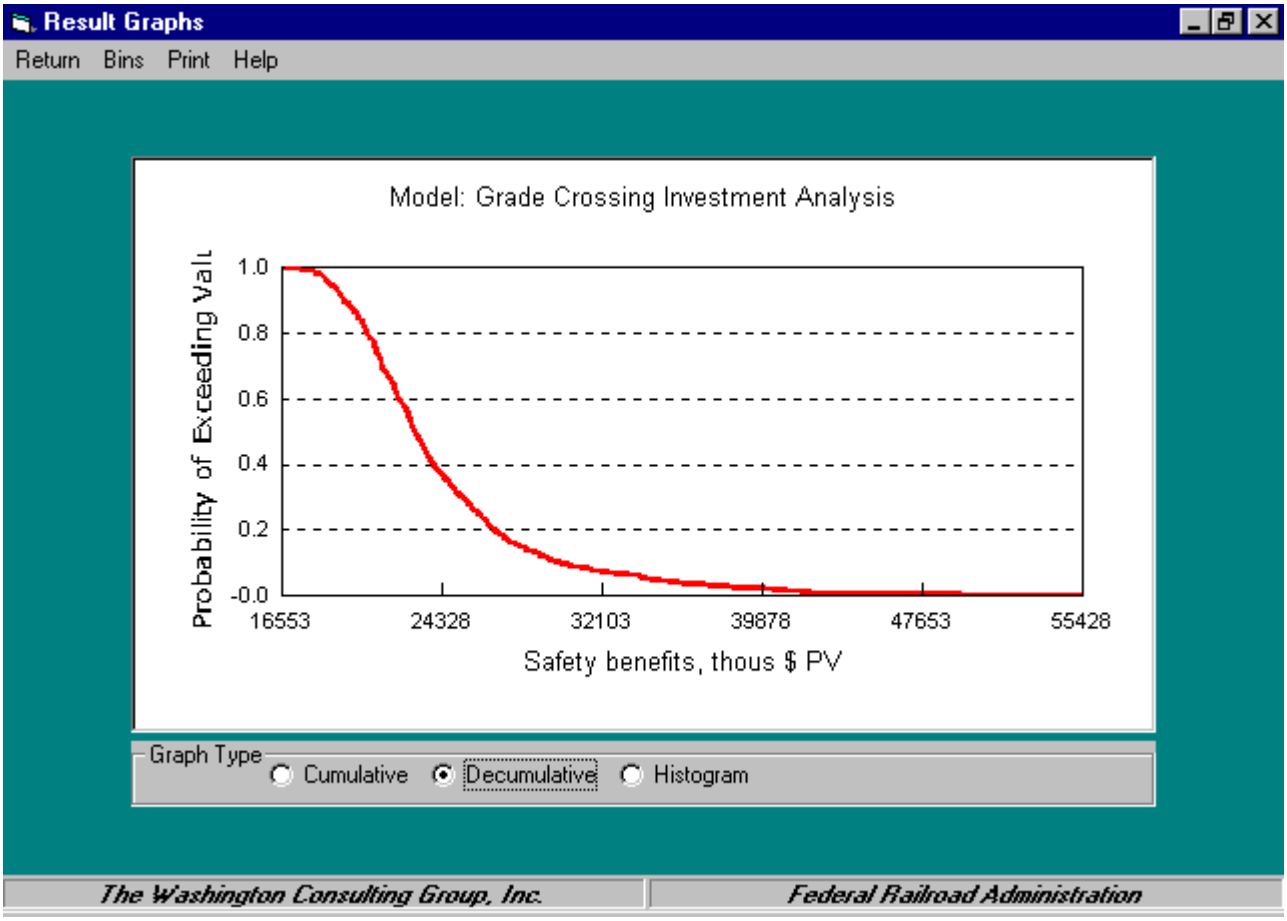

Figure 16 De-cumulative Chart

The cumulative chart, which can be selected by clicking on the cumulative option button below the chart, displays the cumulative probability, that is, the probability that the result is equal to or less than the result value of the range.

Tornado Chart

The tornado chart displays the sensitivity of the risk of a result to the input variables. An input variable contributes to risk by means of: a) its own variance , and, b) its structural role in the GradeDec 2000 model. For instance, an input variable with large variance may not be a significant contributor to the risk of a result while an input variable with small variance may cause the result to be very uncertain and risky. Without the analysis of risk sensitivity it is not easy to determine which factors are the significant contributors to the riskiness of the results.

The tornado chart shows the impact of each random variable input factor when all the other input factors are set to their mean values and the single input factor is allowed to vary within its 80% confidence interval. The tornado chart displays in order the ten input variables that are the major contributors to the risk of a result.

This analysis of sensitivity can guide the analyst to focus on refining the estimates on the range of input variables that truly matter, and, help decisions makers plan for mitigating risks.

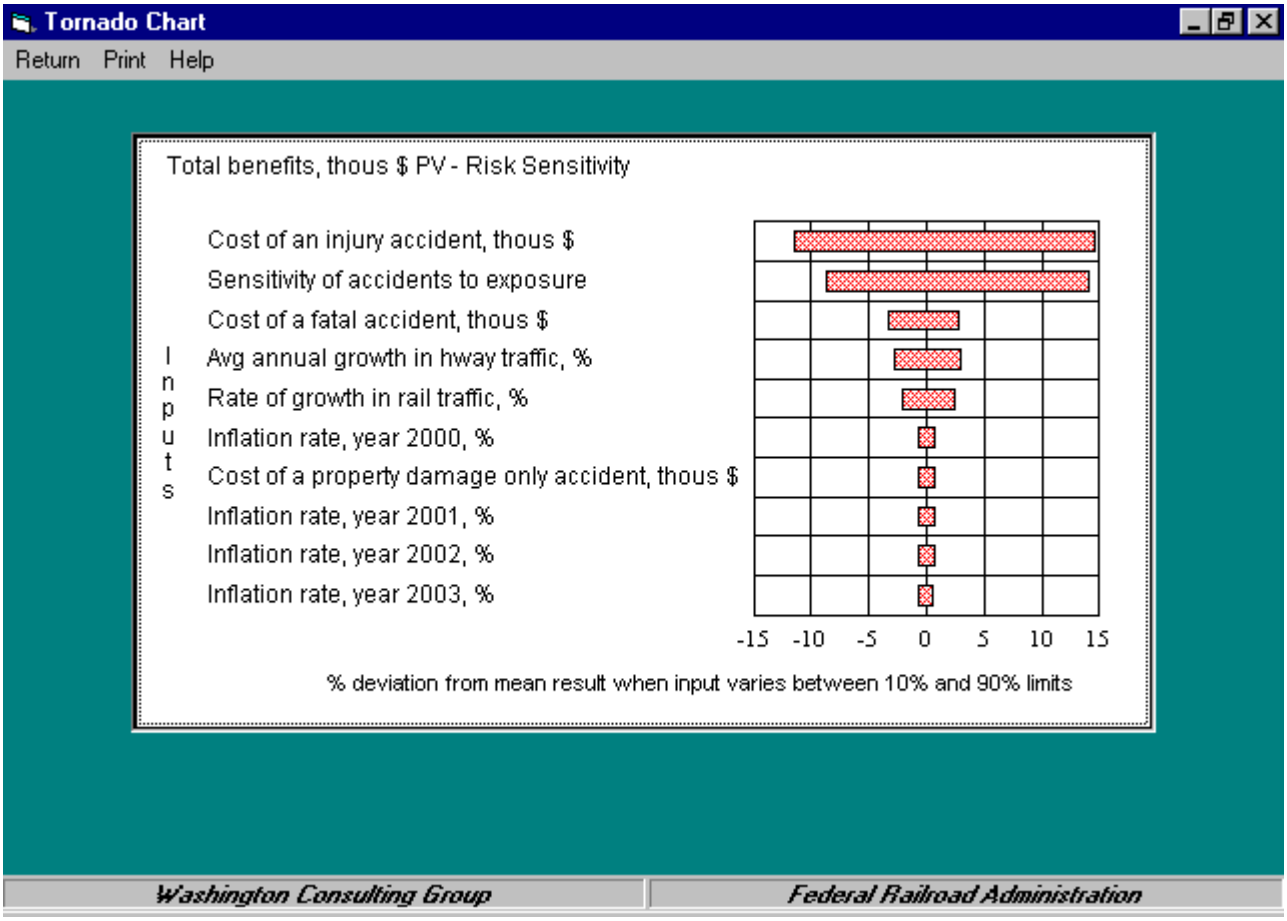

Figure 17 Tornado Chart

Printing Results

The **Results Screen** , large charts and tornado charts can be printed by choosing the print icon in the toolbar (**Results Screen**) or by choosing print from the menus (large charts and tornado charts).

Glossary of Terms

Bins

The range for a simulation result variable, that is, the values bounded by its minimum and maximum values, is divided into equal portions called bins. The result value from each trial "falls" into one of these bins. Charting the result value's range on the horizontal axis and the probability of a result value falling in the bins yields the histogram chart.

Cumulative Probability Distribution

A cumulative probability distribution is constructed by cumulating the frequency of the probability density function. A cumulative probability distribution is an "upwardly sloping" curve, where each point on the curve gives the probability that the variable will be equal to or less than the value on the x-axis. The y-axis of the cumulative probability distribution ranges between 0 and 1. The cumulative probability distribution equals zero for a variable's minimum value and rises to 1 at a variable's maximum value.

De-cumulative Probability Distribution

A de-cumulative probability distribution is constructed by subtracting (or de-cumulating) a variable's probability frequency starting with a probability of 1. A de-cumulative probability distribution is a "downward sloping" curve, where the curve gives the probability of the variable exceeding the value along the X axis. The de-cumulative probability is 1 for a variable's minimum value and is 0 for its maximum value (i.e., the y-axis ranges between 1 and 0).

Deterministic

The term deterministic indicates that there is no uncertainty associated with a given value, variable or model. Models that include random variables are called stochastic.

Histogram

A histogram shows the frequency of a discrete random variable and is used to display the frequency distribution of Monte Carlo simulation result variables. In a histogram, the result values are gathered in bins and the height of the bars correspond to the frequency with which values fall in the respective bins.

Kurtosis

Kurtosis is a statistical measure of a distribution's peakedness. Flatter distributions (with thin tails) are called platykurtic and peaked distributions (with fat tails) are called leptokurtic. The formula for kurtosis is:

$$\frac{\sum_i (x_i - \mu)^4}{\sigma^4} - 3$$

Lower 10% Value

The lower 10% value is the 10th percentile value and is the lower limit of an 80% confidence interval as input by the user.

Mean Value

The mean value for a collection of observations of a random variable is its mean expected value and equals the sum of the observations divided by the number of observations. For skewed distributions, the mean value is off the median value and is located in the direction of the distribution's skew.

Median Value

The median value is the 50th percentile: there is equal probability that the value for a random variable will lie above or below the median.

Monte Carlo

Monte Carlo is the method of sampling from random variables by taking a random number on the 0-1 interval , call it *a*, and finding the value of the random variable whose cumulative probability equals *a*. Repeated Monte Carlo sampling on a number of random variables that are inputs to a model and repeatedly solving the model to arrive at probability distributions for the result variables is called Monte Carlo simulation.

Probability

Probability is the likelihood that a value or event will occur.

Probability Distribution

A probability distribution or probability density function shows a continuous random variable's frequency of occurrence over its range.

Risk

The term refers to uncertainty in a forecast outcome. Colloquially, risk is often associated with undesirable or downside outcomes (as in "hedging against risk"). In a risk analysis, risk is reflected in the probability distributions of result variables.

Risk Analysis

Risk analysis is a term applied to several methods for quantifying uncertainty in forecasts. The risk analysis method used in *GradeDec 2000* is called Monte Carlo simulation.

Random seed

The random seed is a number that initializes the generation of random numbers used in a Monte Carlo simulation. For the same random seed and the same number of trials -- given no change in the model or inputs -- the results of two Monte Carlo simulations will be identical.

Simulation

Simulation is a numeric method for finding solutions to analytically complex problems by "simulating" repeated, real world occurrences.

Skewness

Skewness is a measure of the asymmetry of a distribution. The probability density function of a skewed distribution has a longer tail on its skewed side. A right skewed distribution has skewness greater than 0 and a left skewed distribution has skewness less than 0. The formula for skewness is:

$$\frac{\sum_i (x_i - \mu)^3}{\sigma^3}$$

Standard Deviation

The standard deviation, which is the square root of the variance, is the principal descriptive statistic after the mean value. Knowing only a distribution's mean value and standard deviation, an upper bound can be found on the probability of any value in a variable's range.

Trial

A trial is one solution of a model in a simulation. A simulation consists of many trials. In each trial, every input variable is populated with a data value sampled from the variable's probability distribution.

Upper 10% Value

The upper 10% value is the 90th percentile of a probability distribution and the upper limit of an 80% confidence interval.

Variable

A variable is a model element that can assume more than one value. A fixed-value input variable can assume only one value. A random variable can assume a range of values according to its probability distribution.

Variance

The variance is a measure of the dispersion of values in a probability distribution, and is a measure of risk. The variance is the average of the squared deviations about the mean. The variance gives disproportionate weight to "outliers," values that are far away from the mean. The variance is the square of the standard deviation.

Index